Space Weather Technical Forecast

Issued on Wednesday, 27 September 2023 at 01:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-flares (R1-R2 Radio blackouts) throughout. Slight chance of G1 minor geomagnetic storms early Day 1 (27 Sep).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low, with the largest flare peaking at C5.7 at 26/0428UTC, originating from AR3445.

There are currently eight sunspot regions on the visible disc, with six of these located in the western hemisphere. AR3445 (Dai/Beta) in the south-centre disc is a mixed polarity region and remains the largest and most active. Only small changes in evolution have been observed in recent imagery, although some growth in penumbra was observed. AR3435 (Dsi/Beta-Gamma) and AR3443 (Eso/Beta-Gamma) both remain moderately large bipolar regions, again with slow overall changes in evolution. AR3443 is now rotating around the northwest horizon. AR3447 (Dao/Beta), now nearing south-centre, has continued to show some growth and consolidation. The group of spots that formed to the east of AR3448 have recently been numbered AR3449. Other regions are generally simple and unremarkable.

A filament lift-off around 25/1540 UTC produced a CME to the northwest. This has been analysed to miss the Earth to the west. No other potential Earth-directed CMEs have been observed in the past 24hrs.

Solar Wind / Geomagnetic Activity: Solar winds have been mostly at slightly elevated levels due to the lingering effects of a CME which arrived at Earth on the UTC evening of 24 Sep. Winds have increased to elevated levels since around 26/1300 UTC, and have remained steady around 510-520 km/s. This increase may be as a result of some connection to CH50/-. Density started the period at average levels, rising to above average from 26/1110 UTC with a peak of 23 ppcc at 26/1122 UTC. The Interplanetary magnetic field (IMF), Bt, started off at strong levels around 15nT, before a steady decline through the day has seen Bt become weak, currently at 1-2nT. The north-south component (Bz) was predominantly negative (southward), but has been variable at times, ranging from +10nT to -12nT. Phi angle was predominately positive (away from the Sun) but switched to negative (toward the Sun) from around 26/1000 UTC. Resultant geomagnetic activity was mostly in the range Quiet to Active (Kp 2 to 4), but with G1/Minor Storm (Kp 5) intervals observed between 26/0600-0900 UTC and 26/1200-1500 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background levels. GOES16 high energy (greater than 2MeV) electron flux was at mainly background levels, with a rise to moderate levels during the UTC afternoon. Associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold, showing a recent trend upwards. The observation at 27/0001 UTC was 1.11e7 integrated pfu.

Four-Day Space Weather Forecast Summary

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Solar Activity: Solar activity is forecast to be generally Low, but with a chance of M-class flares, and a slight chance of isolated X-class flares, most likely from AR3445 in the south.

Solar Wind / Geomagnetic Activity: The effects of the recent CME arrival are expected to be minimal, although a possible glance from other weak CME arrivals cant be ruled out early on Day 1 (27 Sep), however this is deemed very low confidence. Solar winds are expected to remain at elevated levels at first, most likely as a result of CH50/-, but should start to drop back to more background levels as any coronal hole influence eases.

Geomagnetic activity will be mostly Quiet to Active (Kp2-4) at first, perhaps with a chance of G1/Minor Storm intervals (Kp5) from any weak CME arrival early Day 1. Activity then likely to ease to Quiet to Unsettled (Kp1-3) levels through the latter half of Day 1 and into Day 2 (28 Sep), with these conditions expected to continue through the rest of the period. There is a possible glancing CME that may give a further enhancement late on Day 2, but this is very low confidence.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a daily slight chance of an enhancement should any larger flares occur.

High energy electron flux (greater than 2MeV) likely to see moderate to high diurnal peaks through the period as any CME influences ease. The associated 24 hour fluence is at background levels and will most likely remain below the Active threshold, although low confidence for later in the period.

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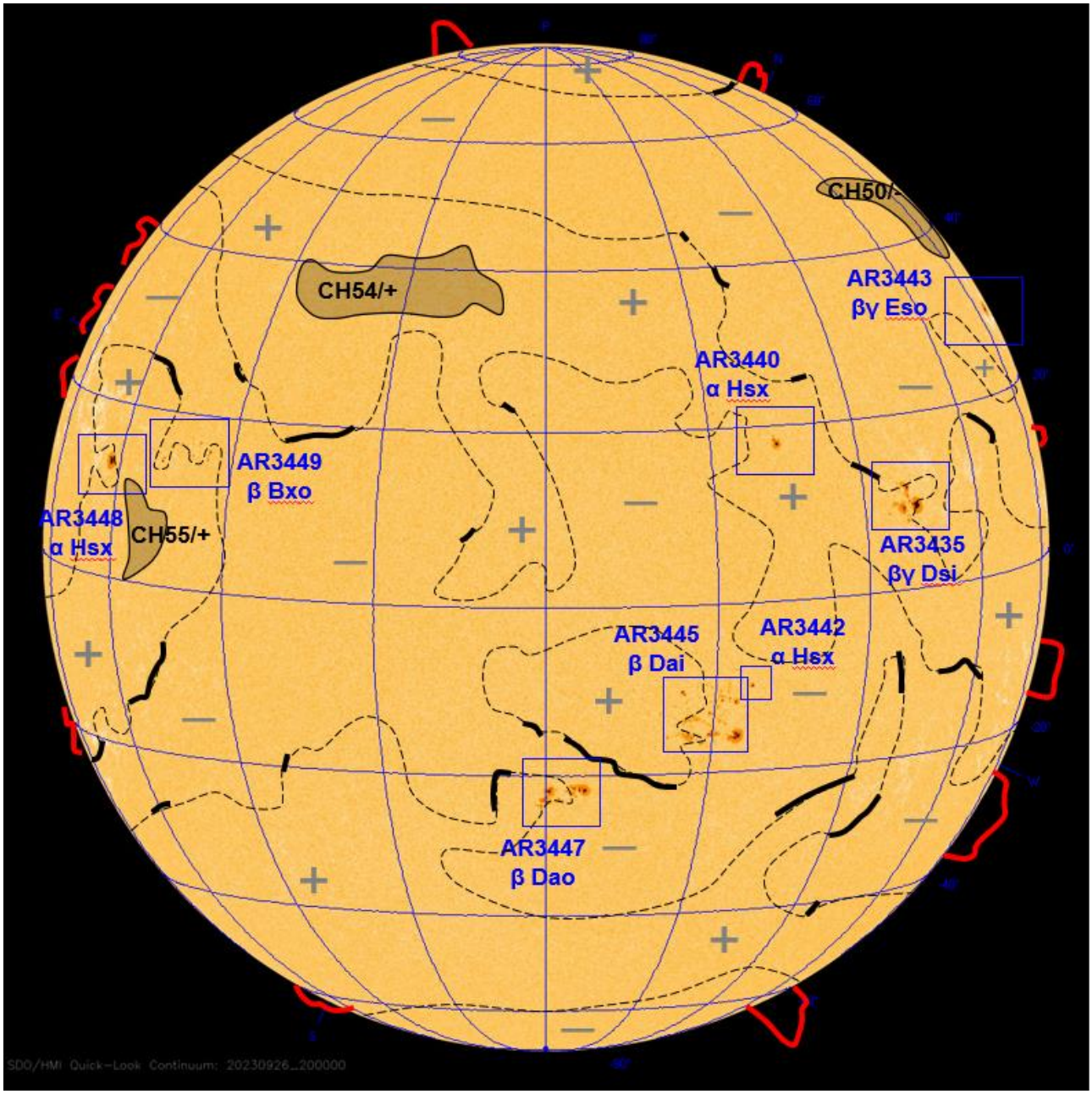
Figure 1. Solar Analysis Valid 26/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There have been a number of CMEs that have left the Sun in the past week, but only one has had an impact at Earth. This CME was associated with the long period M1.2 flare from 22/0336 UTC, and arrived late on 24 Sep. The effects of the CME have since waned. There remains the potential for arrivals from two further CMEs from early on 22 Sep. The first from south of the AR3435/38 complex spot, and a further one to the north of this region. These are both weak eruptions but may give a slight chance of further enhancements early on Day 1 (27 Sep) but this is very low confidence. Other CMEs that lifted off the Sun on 22 Sep are expected to be missing Earth but may give slight glancing impacts, potentially combined within the material in the aforementioned CMEs. The greatest likelihood is that any CMEs that left the Sun on 22 Sep have all either missed the Earth, or were caught up and combined with the one CME arrival that we did see.

Further CMEs were observed leaving the Sun from the western limb on 24/25 Sep. Most are far-sided, with a suggestion one could give a weak glancing blow late on Day 2 (Sep 28), but this is deemed unlikely and treated as very low confidence.

Solar winds are expected to remain at elevated levels at first, most likely as a result of CH50/-high speed stream. As this coronal hole rotates further west its connection to Earth is likely to ease, with solar winds likely dropping back to more ambient levels with no other obvious coronal holes predicted in the forecast period.

Overall this gives a slightly reduced confidence in the geomagnetic forecast. Geomagnetic activity will initially be Quiet to Active (Kp 2-4) with a chance of G1/Minor Storm (Kp 5) intervals early on Day 1 (27 Sep) due to waning CME effects, and also possible further glancing CME effects. Quiet to Unsettled (Kp1-3) activity is then expected to dominate from later Day 1 (27 Sep) through the rest of the period. However, a further enhancement is possible late on Day 2 (28 Sep) with another potential glancing CME, but this is very low confidence.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	20	20	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/1134	Partial	Filament	NW	592 km/s	Early 27 Sep	Missing/glancing
22/1504	Partial	Filament	SW	497 km/s	Early 27 Sep	Missing/glancing

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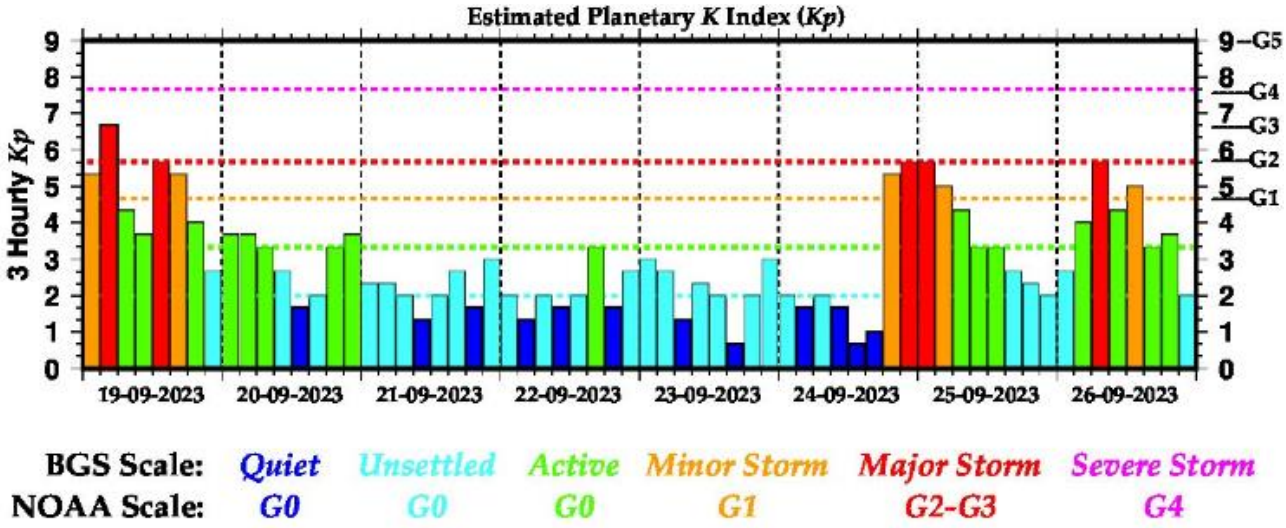
Figure 2: BGS plot of geomagnetic activty over the past 7 days.



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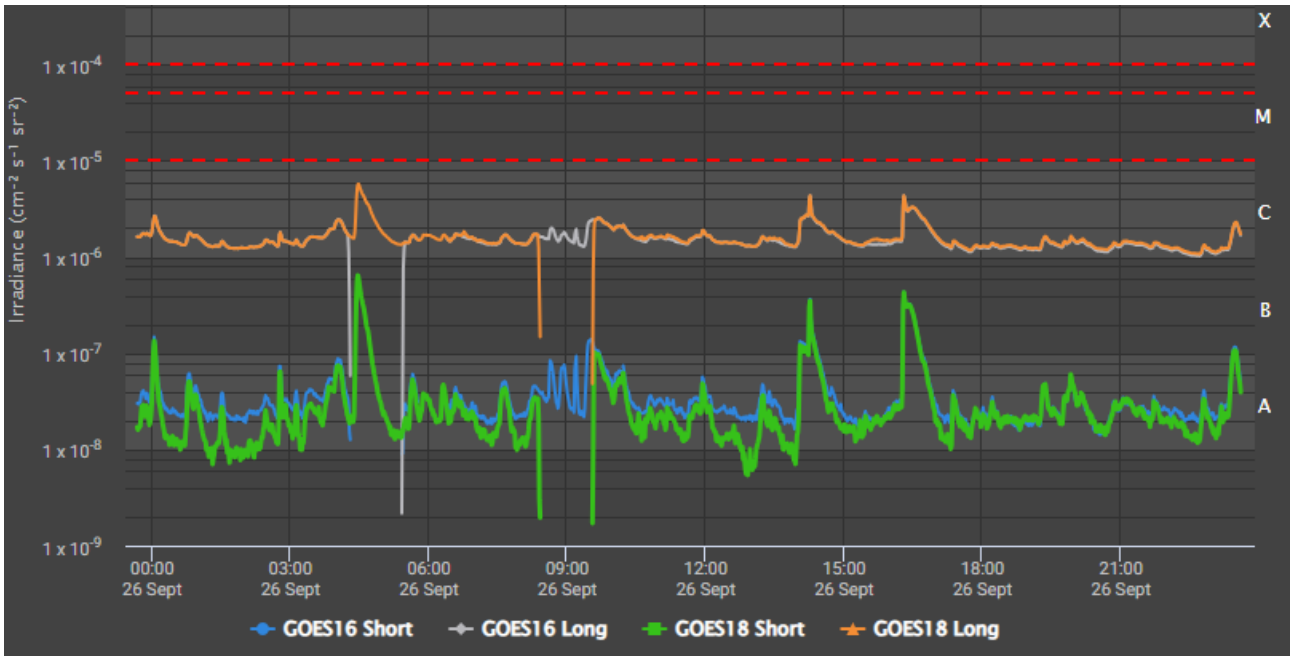
Radio Blackouts - X-Ray Flares:
Solar activity has been Low. The largest flare was a C5.7 flare at 26/0428UTC, originating from AR3445. There remains a chance of further M-flares, with a slight chance of an X-flare, most likely from AR3445.

There are currently eight sunspot regions on the visible disc, with six of these located in the western hemisphere. AR3445 (Dai/Beta) in the south-centre disc is a mixed polarity region and remains the largest and most active. Only small changes in evolution have been observed in recent imagery, with some growth in penumbra. AR3435 (Dsi/Beta-Gamma) and AR3447 (Dao/Beta) both remain moderately large bipolar regions, again with slow overall changes in evolution. Only the trailer portion of AR3443 is now visible as this region rotates around the northwest horizon. AR3447 (Dao/Beta), now nearing south-centre, has continued to show some growth and consolidation. Other regions are generally simple and unremarkable.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: GOES 16/18 X-ray flux.



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is likely to persist at background levels, however there are regions moving across the western disc which bring a chance of flux levels rising above background given the occurrence of any significant flares. This includes AR3443 and AR3435, as well as AR3445 in the south.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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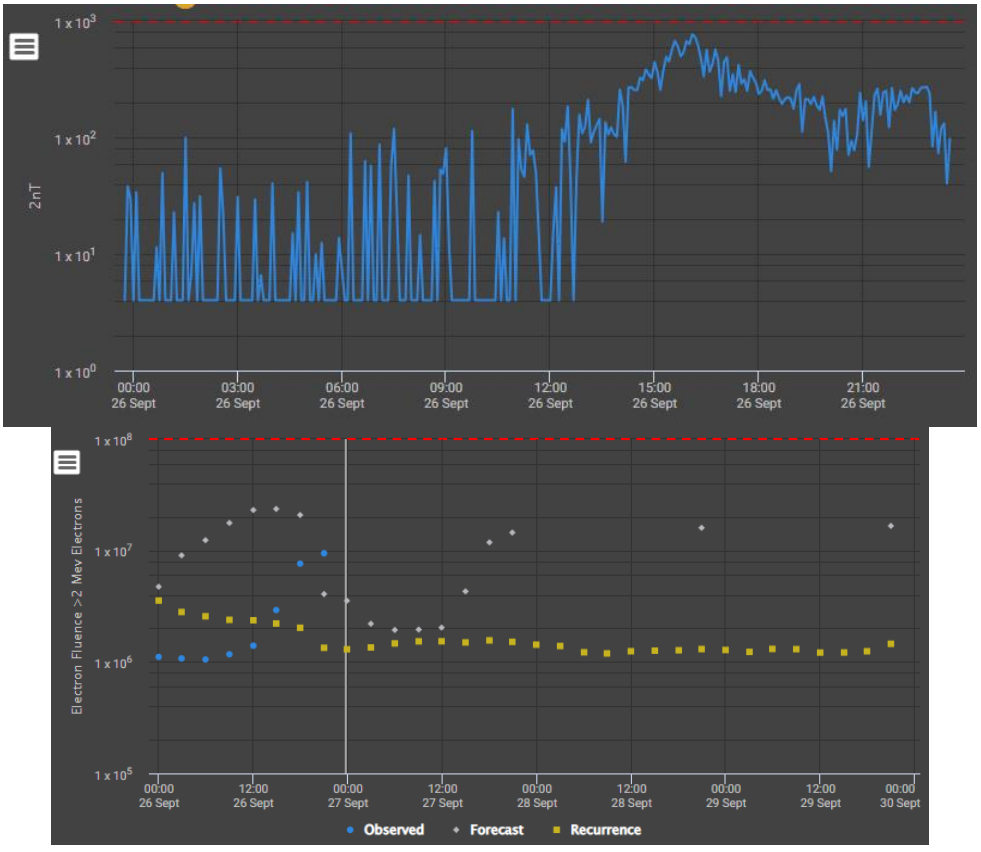
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) observed by GOES16 has seen a rise to moderate levels as the effects of the CME arrival on 24 Sep wane. Any further CME glancing blows may see the electrons suppressed once again, but this is deemed low confidence, and moderate to high diurnal peaks in electron flux are probable in the coming days, most likely from Day 2 (28 Sep) onwards.

The associated 24 hour fluence is at background levels and is expected to remain below the Active threshold at first. Any increasing trend from Day 3 (29 Sep) onwards is low confidence. REFM is currently giving reasonable overall guidance of the expected trend in the coming days, remaining below Active throughout.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES 16 Electron flux and MOSWOC REFM output.



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